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Studies on the Preparation of Fish Silage

II. Rate of Liquefaction in different parts of Silver Belly

By

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Introduction

In part I of this study to determine the technical and economic feasibility of producing fish silage commercially in Sri Lanka (Jayawardena *et al*, 1980), the quality and storage life of silages made from silver belly of different initial quality and with different acids was investigated. The present paper presents the results of an experiment to determine from which part of the fish carcass the autolytic enzymes responsible for liquefaction mainly originate. The storage life of silages produced from various parts of the fish carcass using 3.5% formic acid is also reported.

Materials and Methods

Fish Samples

Silver belly (*Leiognathus splendens*) locally known as "Karalla" were used. They were caught in November, 1978 during prawn trawling operations off the Jaffna coast. The fish were iced on landing and transported to Colombo where they were frozen. After 6 weeks of storage at— 25°C the fish were thawed, the carcass composition was determined and silages produced from the various parts.

Carcass Composition

Fish (25) were selected at random and the body length and weight determined. Each fish was then carefully dissected and the parts, i.e. flesh, head, frame, skin, viscera and fins weighed separately. The carcass composition (% w/w) was calculated.

Preparation of Silage

Table 1 gives details of the carcass parts used to produce the 6 silage samples. The various parts for any one sample were mixed together in the same proportion as they occur in whole fish and approximately 1 kg was ground in an electric mincer. Formic acid, 3.5% w/w of an 85% w/v solution, was added to the mince and thoroughly mixed by hand. The samples were stored in 2 litre plastic containers with loose fitting lids at an ambient temperature of 28°C to 30°C.

Analytical methods

Water, ash, fat, total nitrogen, crude protein and pH were determined as described previously (Jayawardena *et al.* 1980).

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Degree of Autolysis

The increase in autolysis with time in the silage samples was estimated in 2 ways. Firstly, the degree of liquefaction was determined by centrifuging the samples in an IEC bench centrifuge at 3,000 rpm for 30 minutes. The supernatants were carefully removed and weighed. The weight of the liquid phase was expressed as a percentage of the total weight of sample. Secondly, the non-protein nitrogen (NPN) content of the silage samples was measured. Protein nitrogen in 2 g samples was precipitated by adding 50 ml of 10% tri-chloroacetic acid and removed by filtering. The amount of NPN contained in 20 ml of the filtrates was determined using the standard micro-kjeldahl procedure (Pearson, 1970) and expressed as a percentage of the total nitrogen.

Results and Discussion

The mean weight of 25 silver belly was 8.1g (range 5.8 to 10 .5g) and the mean length was 6.9 cm (range 6.0 to 8.0 cm). The carcass and chemical composition (means of duplicate analyses) of the fish are given in Table 2.

Silver belly is a small, mesopelagic fish with a low fat content in the flesh. However, the fat content of the viscera is relatively high as is the ash content. Up to 60% of the latter may be sand (Etoh, 1979).

The appearance and odour of the silage samples at 1, 2, 11 and 64 days after producton is given in Table 3. The silage made from flesh only became putrid after 10 days and the silage containing viscera showed growth of yellow moulds after 55 days. The other samples remained in an acceptable condition for 64 days.

Table 3 also shows that there were significant differences in the rate of liquefaction of the samples. The whole fish liquefied most rapidly followed in turn by the sample containing viscera, the sample containing heads, the sample containing skin, the sample with flesh/frames/fins and finally by the sample containing only flesh.

The same pattern is clearly shown in Figure 1 which gives the changes in the NPN contents of the samples.

Together these results give an indication of the concentration and activity of the proteolytic enzymes contained in the various carcass parts. It is these autolytic enzymes rather than the added formic acid which breakdown the structural proteins into smaller water soluble units and brings about the liquefaction of the samples. It appears that in order to obtain a liquid product it is necessary to have viscera and/or heads present.

The NPN content of the flesh-only silage sample was quite low until the 10th day after production when there was a sudden increase. This coincided with the occurrence of off putrid odours in the sample and was probably due to the production of low molecular weight nitrogenous compounds such as amines.

Figure 2 shows the changes in the weight of the aqueous phase of the samples during storage. Although the pattern is not so distinct as in Table 2 of Figure 1, the results show that silage samples containing viscera or heads had a larger aqueous phase than the samples without these parts. No aqueous phase at all could be separated from the flesh-only sample by centrifuging.

In general, it was extremely difficult to obtain a clear separation of the aqueous and sedimentary phases by centrifuging for 30 minutes at 3,000 rpm. Indeed, there were often more than 2 phases apparent and the nature of these phases changed as the period of storage increased. Initially the

aqueous phase consisted of a clear fluid but after 2 days this liquid became more viscous and less easy to separate from the gel-like sedimentary phase. This accounts for the initial drop in the curves given in Figure 2. On further storage the aqueous phase increased again. After a few days however, 4 phases were to be seen after centrifuging ; a lipid layer, a clear aqueous layer, a thick viscous layer containing suspended solids and a layer containing pieces of bone, connective tissue etc. There was no real margin between layers 2 and 3 which led to a certain amount of variability in the results.

Table 4 gives the chemical composition of the silages 4 weeks after production and their aqueous phase 9 weeks after production. The nitrogen content, rather than crude protein content, is given since the conversion factor of 6.25 may not be applicable when up to 60% of the nitrogen appears in the NPN fractions. There was very little difference in the chemical composition of the silages or theie aqueous phases other than the fact that the silages containing heads had a rather high ash content.

Table 5 gives the pH of the silages at 1, 2, 11, and 64 days after production. As reported earlier (Jayawardena *et al.*, 1980) the pH of formic acid silage rises slightly after production. A small rise is acceptable but a large rise indicates spoilage of the sample ; for example the flesh - only silage which went putrid had a pH of 8.2 and the silage containing viscera which showed mould growth had a pH of 4.6.

Conclusions

1. In order to get a satisfactory liquefaction in silage prepared from silver belly using 3.5% formic acid, it is necessary to have the viscera or heads present. Exclusion of these parts means that liquefaction, if it does occur, is very slow and that even mixing of the acid is difficult to achieve. This will result in the silage being more susceptible to microbiological spoilage.

2. Provided it may be mixed in easily, 3.5% formic acid is sufficient to prevent spoilage for up to 2 months in silages produced from good quality fish. However, such silages may be susceptible to mould attack, particularly on prolonged storage.

3. Measurement of changes in NPN content is the best objective method for assessing changes in the degree of liquefaction and autolysis.

4. Measurement of pH changes gives a good indication of whether the quality of the silage is deteriorating.

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TABLE 1

DETAILS OF CARCASS PARTS IN THE SILAGE SAMPLES

Sample	*Carcass Parts*				
1	Flesh	Frame	Fins	Viscera	Head	Skin
2	Flesh	Frame	Fins	Viscera	—	—
3	Flesh	Frame	Fins	—	Head	—
4	Flesh	Frame	Fins	—	—	Skin
5	Flesh	Frame	Fins	—	—	—
6	Flesh	—	—	—	—	—

TABLE 2

CARCASS AND CHEMICAL COMPOSITION OF SILVER BELLY

Sample	*Carcass Composition* % (*w*/*w*)	*Water* % (*w*/*w*)	*Ash* % (*w*/*w*)	*Fat* % (*w*/*w*)	*Crude Protein* % (*w*/*w*)	*NPN* % (*w*/*w*)
Whole fish	100	74.2	5.5	3.0	17.6	—
Flesh	36.9	75.3	1.1	2.7	22.7	0.1
Head	22.2	69.4	10.0	5.3	21.8	0.1
Frame	16.6	59.8	12.8	5.8	23.1	0.2
Skin	6.2	67.8	2.0	6.7	25.0	0.2
Viscera	6.1	61.3	13.7	9.8	13.1	0.2
Fins	1.5	54.9	21.3	1.2	21.0	0.1

TABLE 3

APPEARANCE AND ODOUR OF SILAGE SAMPLES

Silage Samples	*Time of Storage (Days)*			
	1	*2*	*11*	*64*
Whole fish	Dark grey, Moist	Dark grey, Semi-liquid	Dark grey, Liquid	Dark grey, Liquid, Malty/acidic odour
Flesh/Frame/Fins/Viscera	Light grey, Moist	Light grey, Semi-liquid	Light grey, Liquid	Yellow moulds, Liquid, Strong mouldy odour
Flesh/Frame/Fins/Head	Dark grey, Slightly moist	Dark grey, Semi-liquid	Dark grey, Liquid	Dark grey Liquid, Fresh acidic odour
Flesh/Frame/Fins/Skin	Grey, Very slightly moist	Grey, Dry paste	Grey, Slightly moist paste	Grey, Slightly moist paste Acidic odour
Flesh/Frame/Fins	Light grey, Dry	Light grey, Dry paste	Light grey, Dry paste	Light grey, Moist paste, Acidic odour
Flesh	Off white, Dry	Off white, Dry	Creamy brown, Moist, Putrid odour	Discarded

TABLE 4

CHEMICAL COMPOSITION OF WHOLE SILAGE SAMPLES FOUR WEEKS AFTER PRODUCTION AND SILAGE AQUEOUS PHASES NINE WEEKS AFTER PRODUCTION

Silage Sample	*Water % (w/w)*		*Ash % (w/w)*		*Nitrogen % (w/w)*	
	Whole Sample	*Aqueous Phase*	*Whole Sample*	*Aqueous Phase*	*Whole Sample*	*Aqueous Phase*
Whole fish ..	72.1	83.7	7.4	2.9	2.8	1.8
Flesh/Frame/Fins/Viscera	74.4	83.9	5.2	2.7	2.9	1.9
Flesh/Frame/Fins/Head	71.1	85.2	7.2	2.8	2.7	1.6
Flesh/Frame/Fins/Skin	74.0	86.2	4.0	2.5	3.1	1.7
Flesh/Frame/Fins ..	74.4	86.6	4.5	2.4	3.0	1.6
Flesh ..	No aqueous phase—sample discarded after 11 days					

TABLE 5

CHANGE IN pH OF SILAGE SAMPLES WITH TIME

Silage Sample	*Time of Storage (Days)*			
	1	*2*	*11*	*64*
Whole fish ..	3.6	3.8	3.8	4.0
Flesh/Frame/Fins/Viscera ..	3.6	3.8	3.8	4.6
Flesh/Frame/Fins/Head ..	3.6	3.8	3.8	4.0
Flesh/Frame/Fins/Skin ..	3.5	3.7	3.7	3.8
Flesh/Frame/Fins ..	3.5	3.7	3.7	3.8
Flesh	3.7	3.9	8.2	—

FIGURE 1

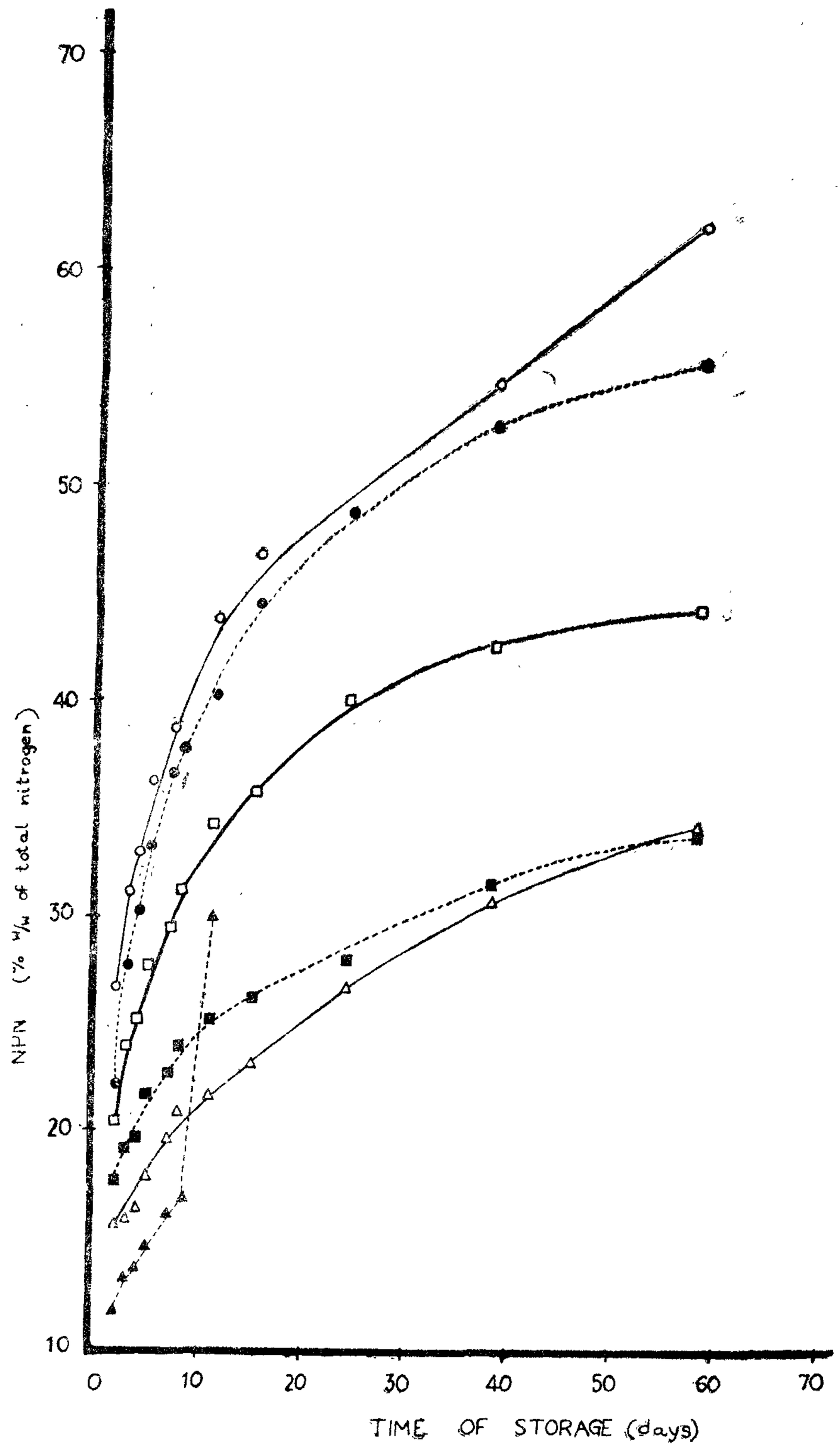

Figure 1.— Change in NPN content (% w/w of total nitrogen) of silages during storage. Whole fish (○), sample containing viscera (●), sample containing heads (□), sample containing skin (■), sample with flesh, frame and fins (△), flesh only sample (▲)

Figure 2

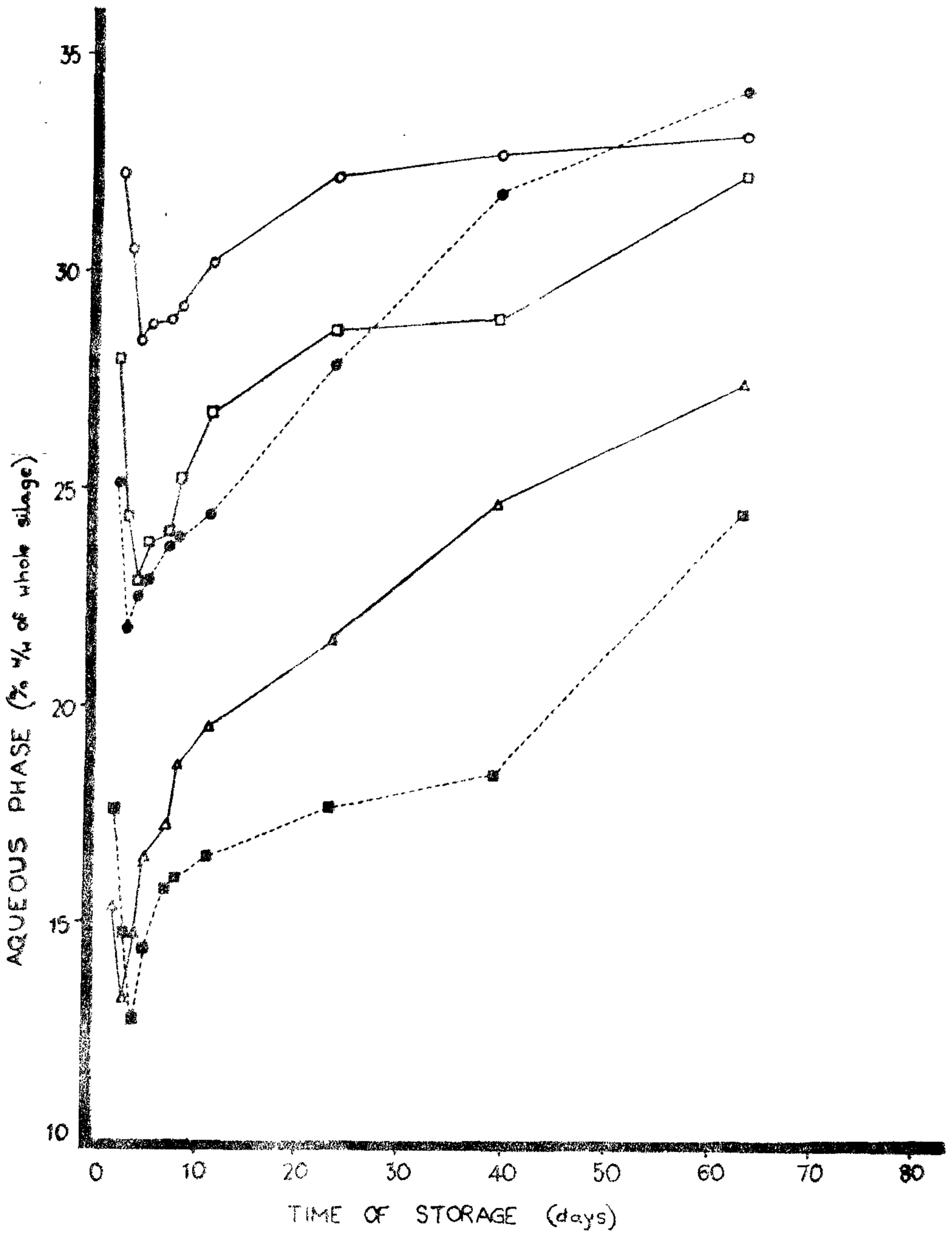

Figure 2— Change in weight of aqueous phase (% w/w of whole silage) of silages during storage. Whole fish (○) sample containing viscera (●), sample containing heads (□), sample containing skin (■), sample with flesh, frame and fins (△)